

Design and Lessons Learned on the Development of a Cryogenic Pupil Select Mechanism (PSM)



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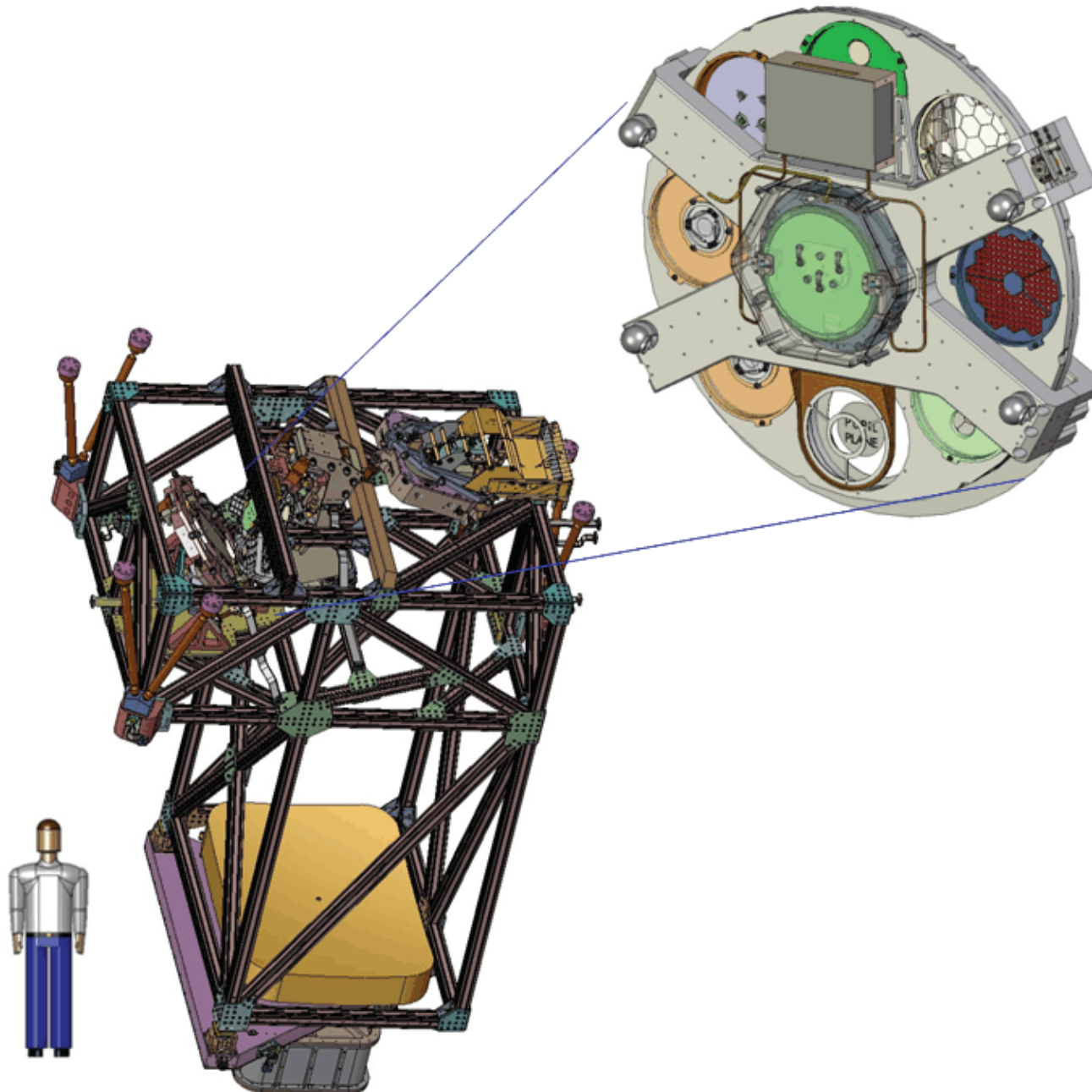
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Design Interface, Inc.

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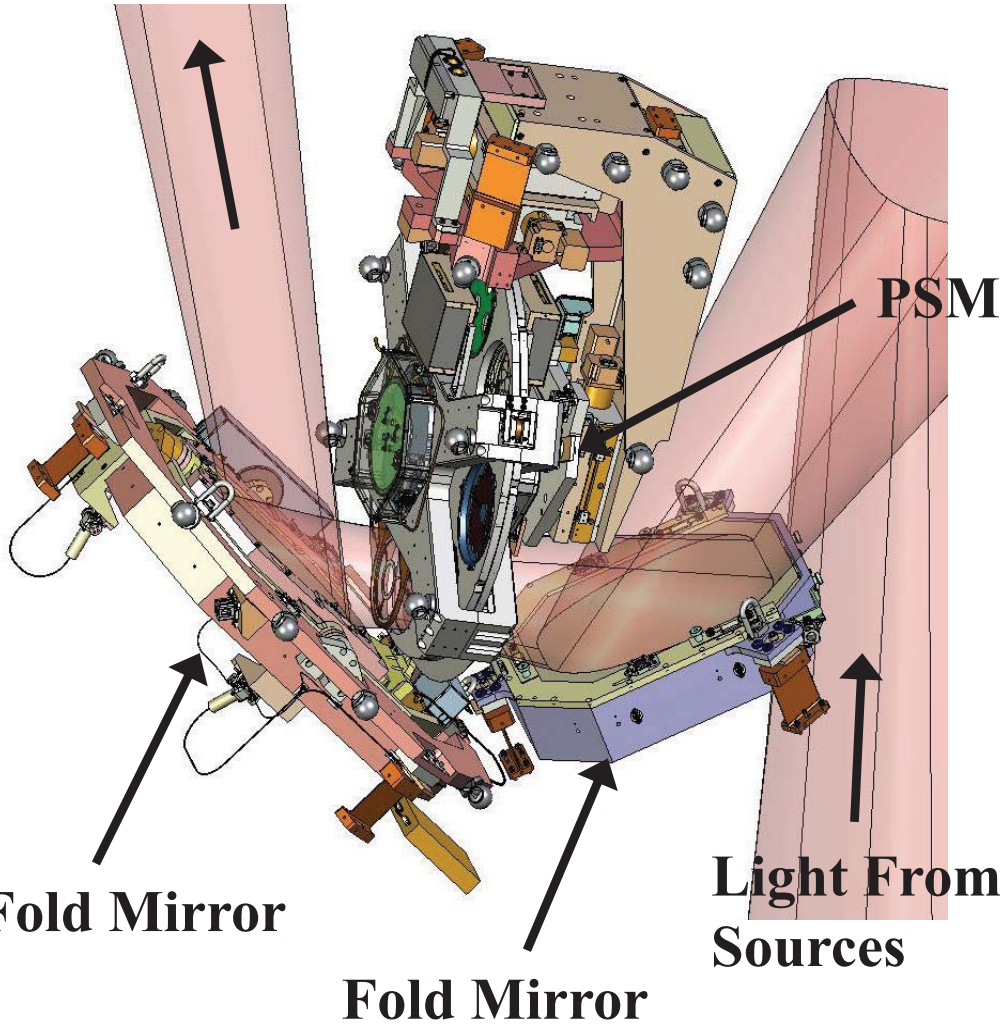
What is the PSM?



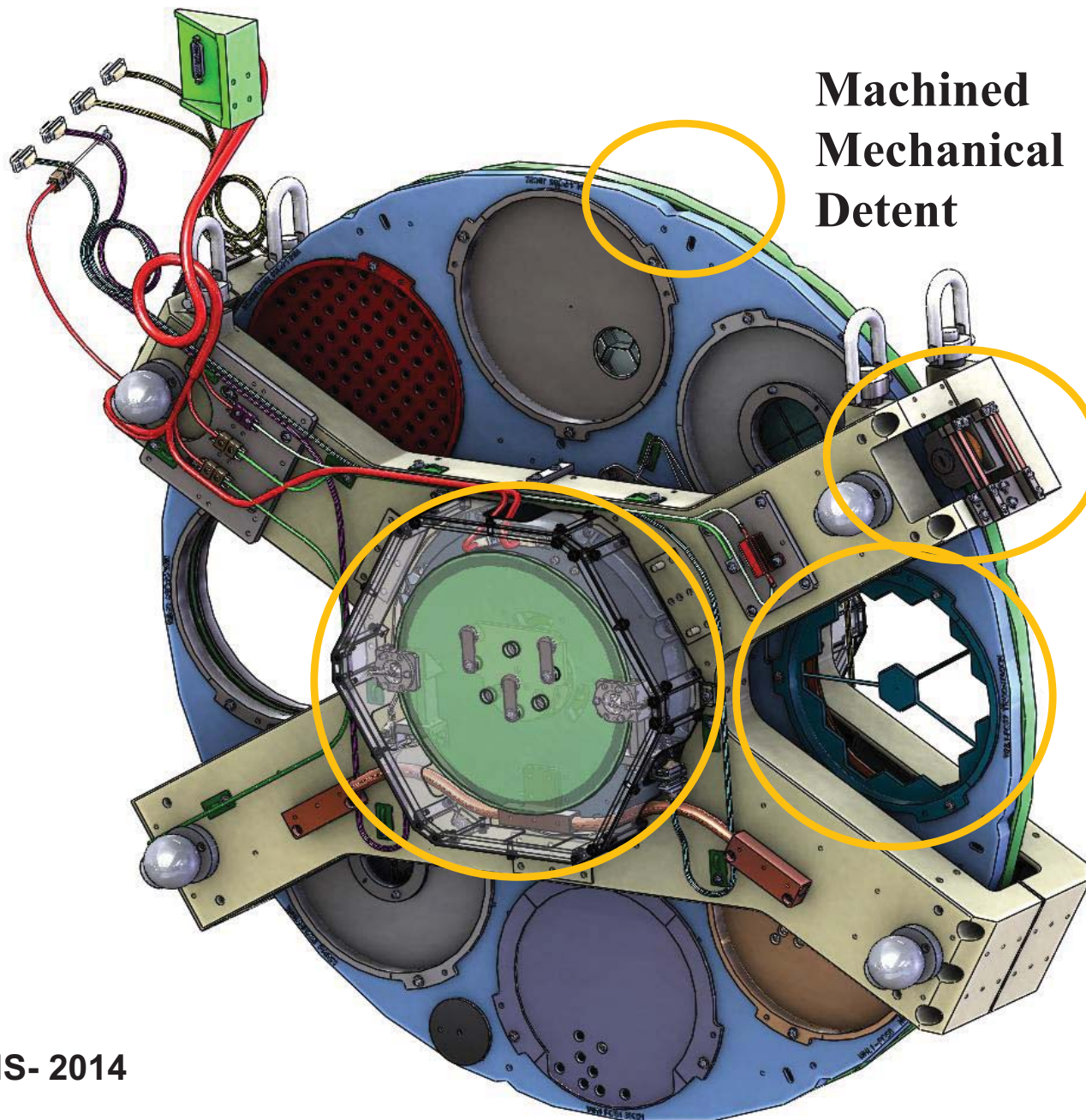
What Does the PSM Do?



Light to ISIM



As-Built Design Features



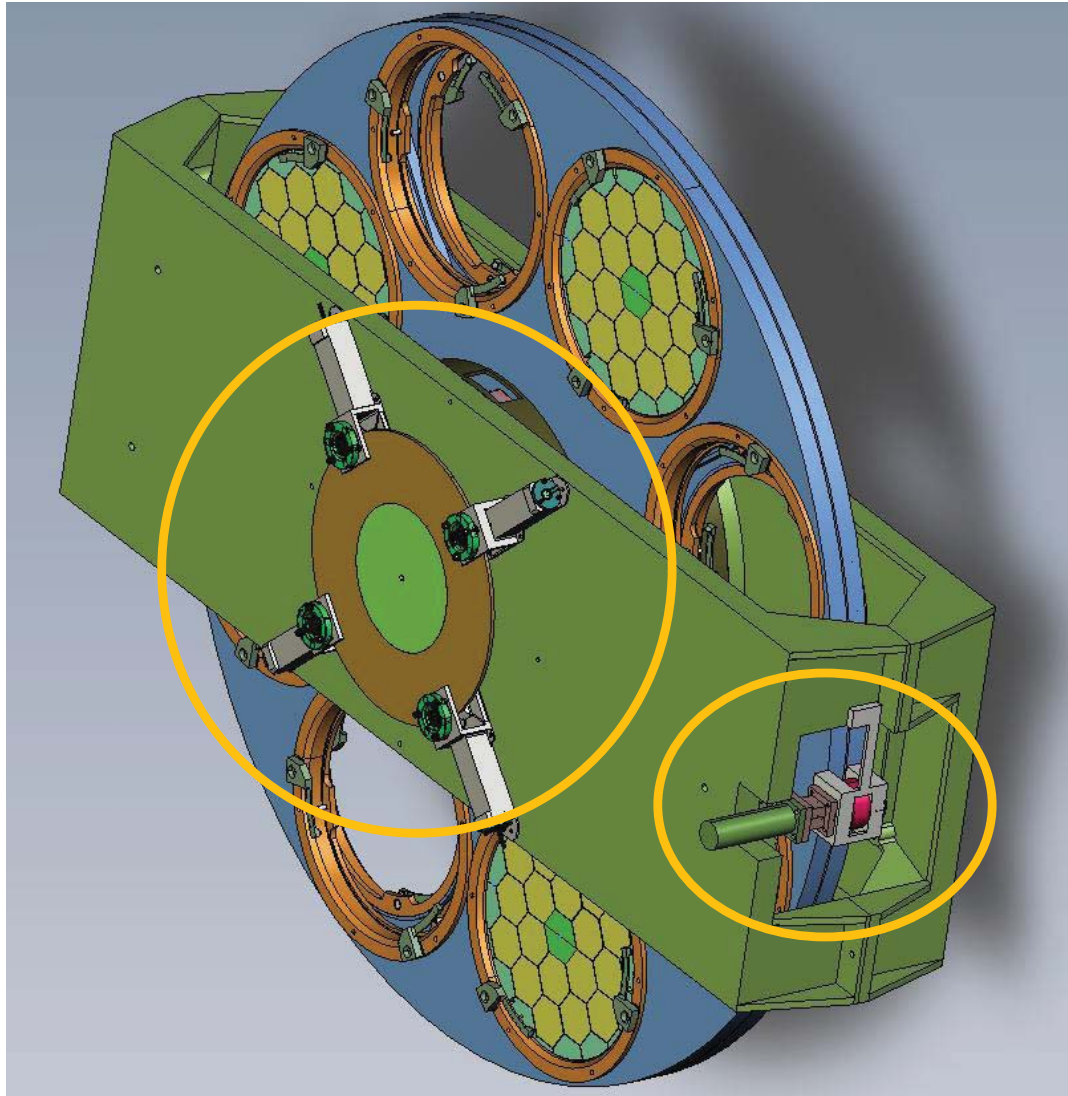
**Machined
Mechanical
Detent**

**Detent Follower
Assembly**

**7 Optical Elements in
Each Wheel**

**Direct Drive BDC
Motor, Titanium
Drive Housing,
Encoder**

PSM Design: Initial Concept



**Absolute Encoder
Provided High
Knowledge Accuracy
Information**

**Stepper Motor with High
Gear Ratio Preloaded on
Wheel, Driving through
Friction**

So, What Went Wrong?



Several concerns led to changes in design from the initial concept

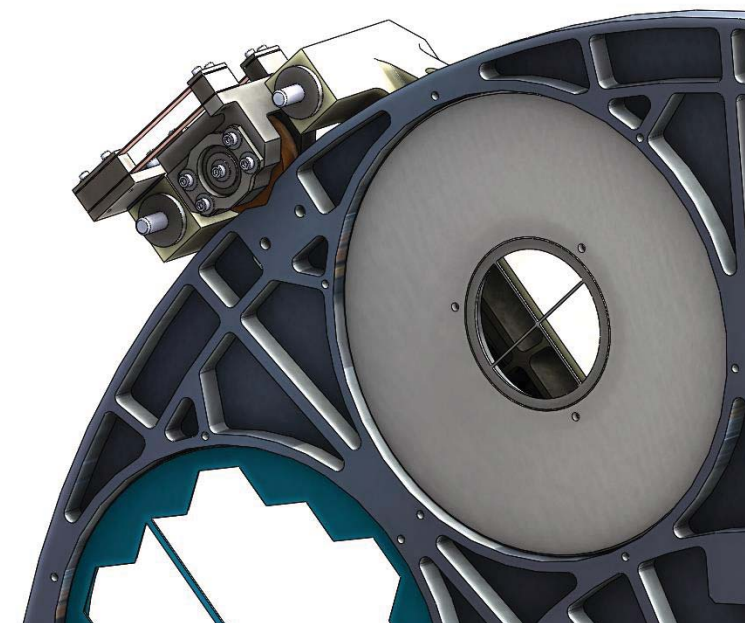
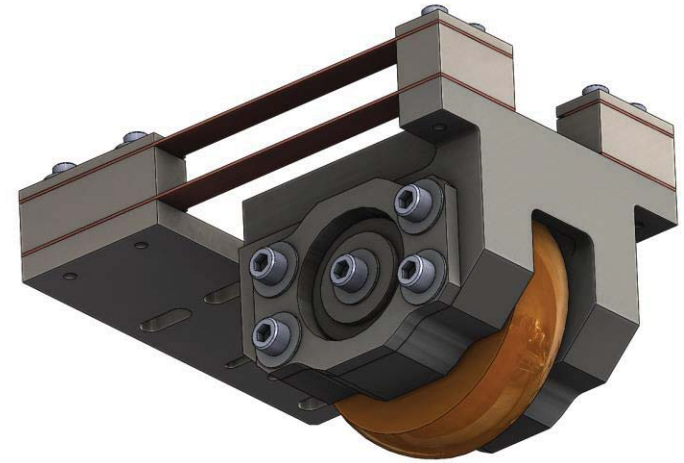
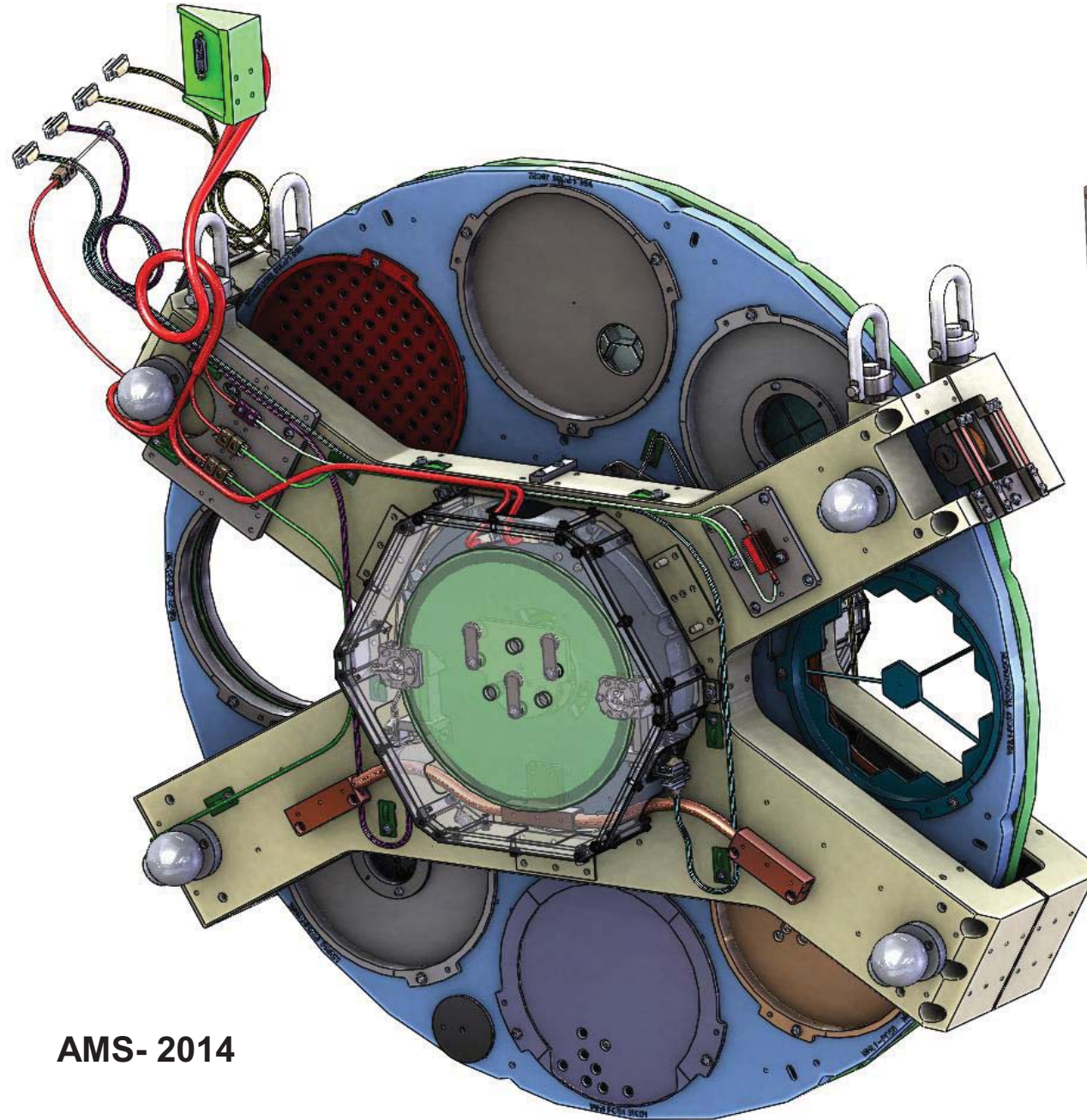
- Motor Life**
- Power Dissipation**
- Variability of Friction at Cold Temperatures**
- Potential Motor Drive Wheel Slip**

Design Modification Constraints



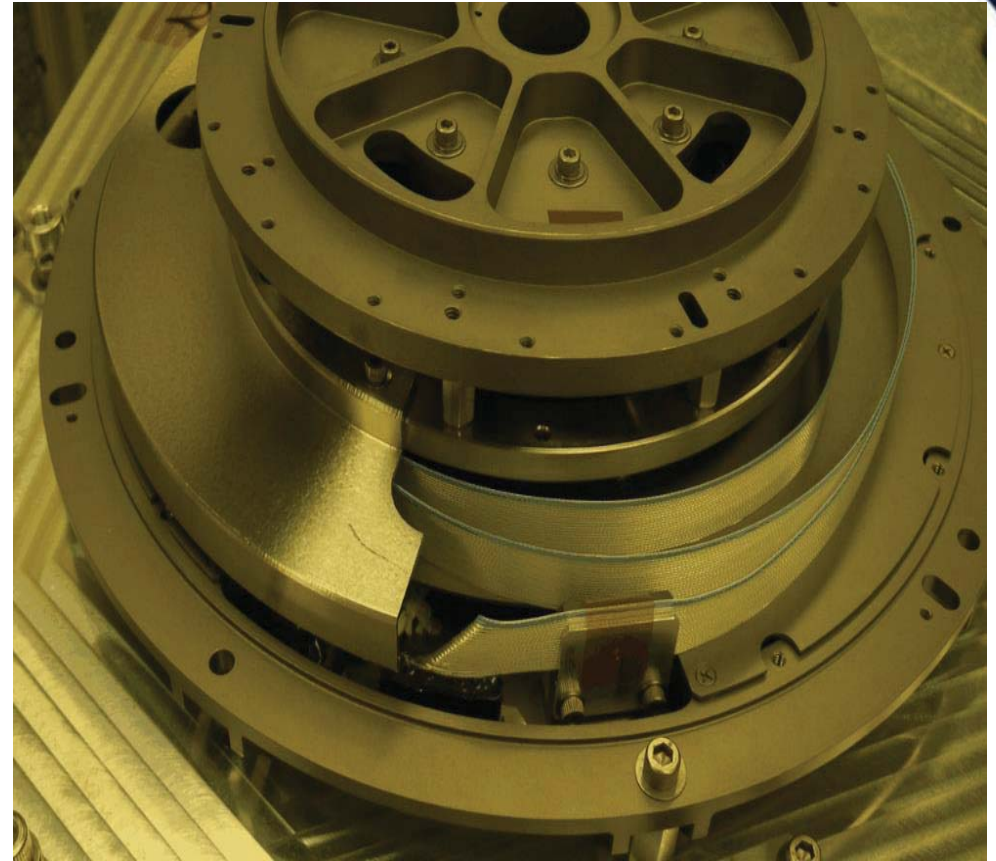
- **Constrained Development Schedule**
- **Long Lead Item Fabrication Had Started**
 - **Bearing Procurement**
 - **GSFC Developed Cryogenic Encoder**
- **Minimal System Impact**
 - **Maintain Wire Count**
 - **Utilize Existing Motor Driver**

PSM Re-Design

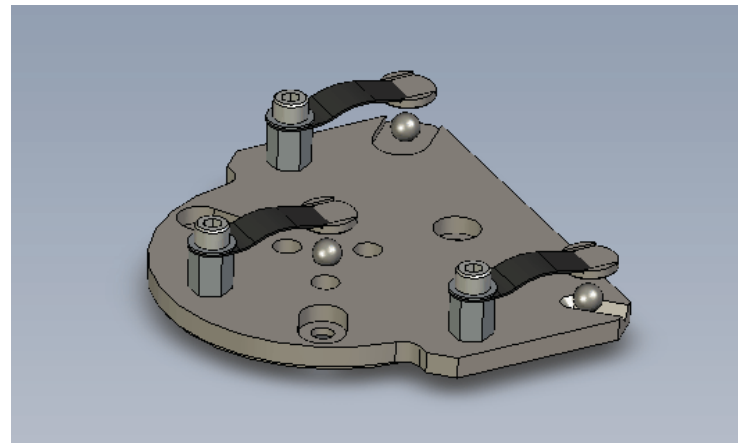
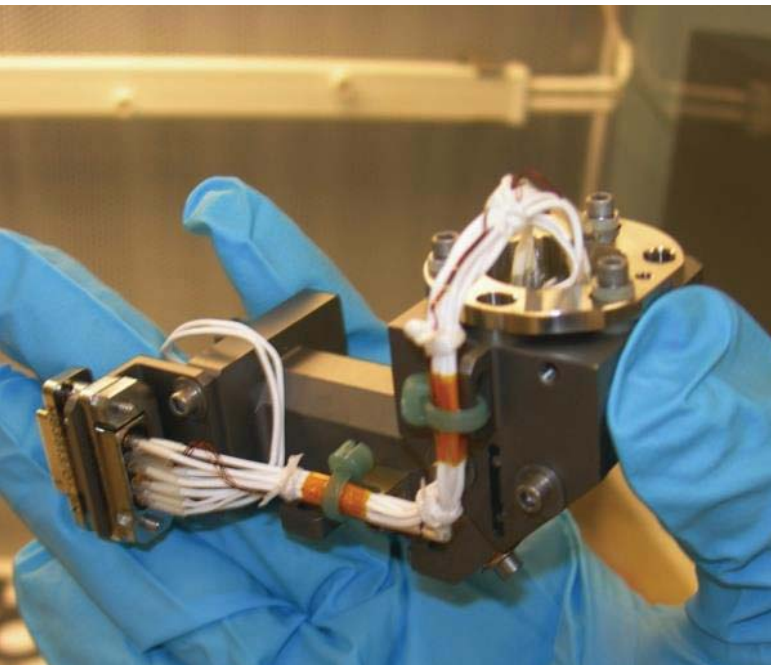
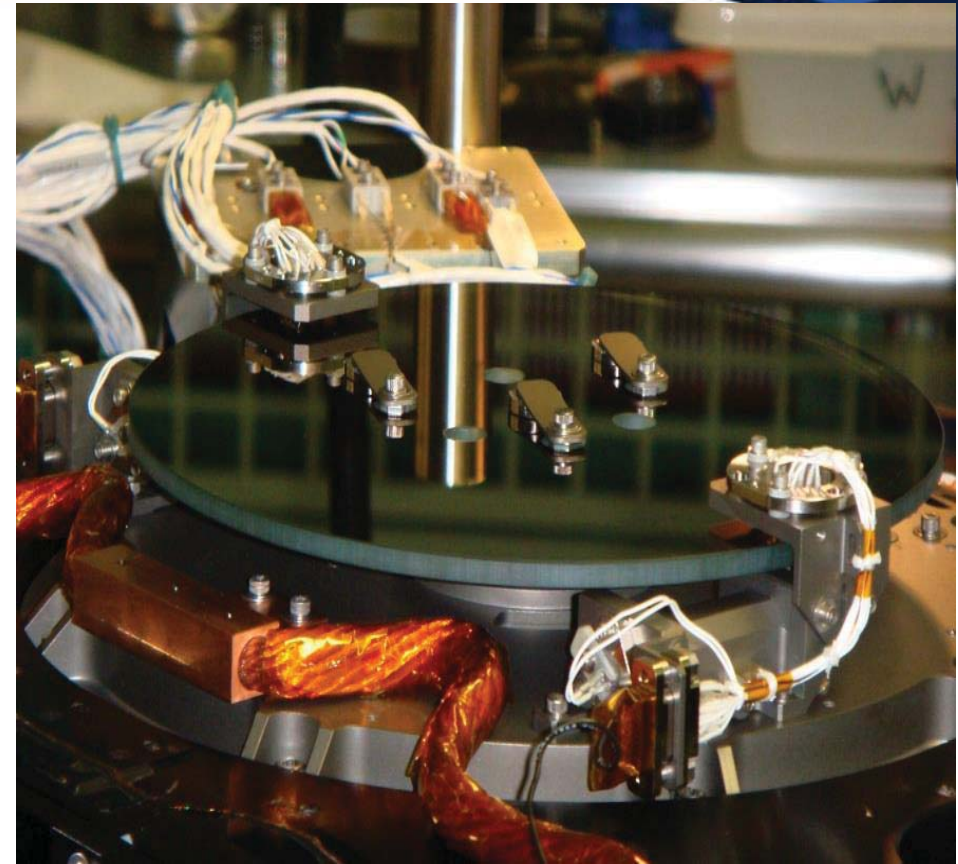
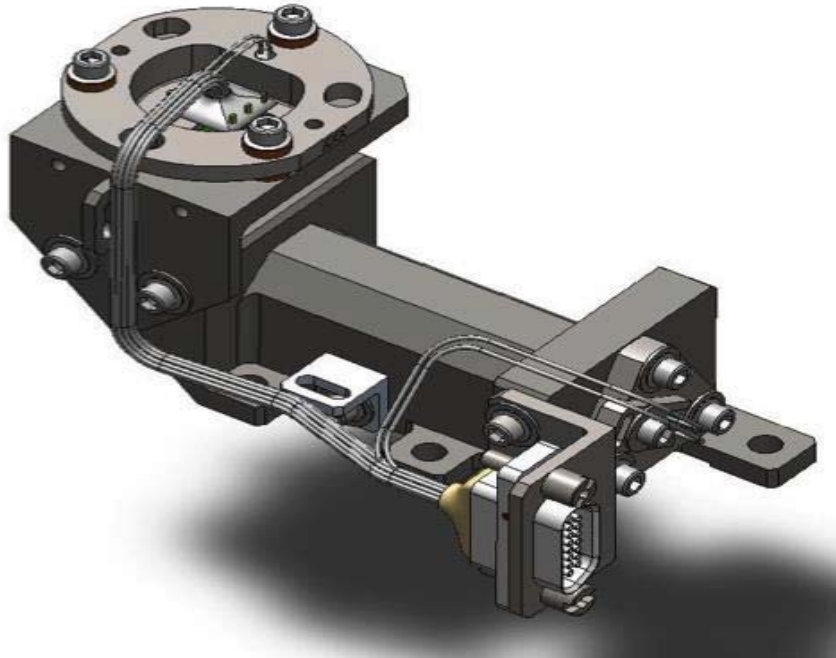


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PSM Build: Motor Assembly/ Cable Drum



Encoder Assembly and Alignment



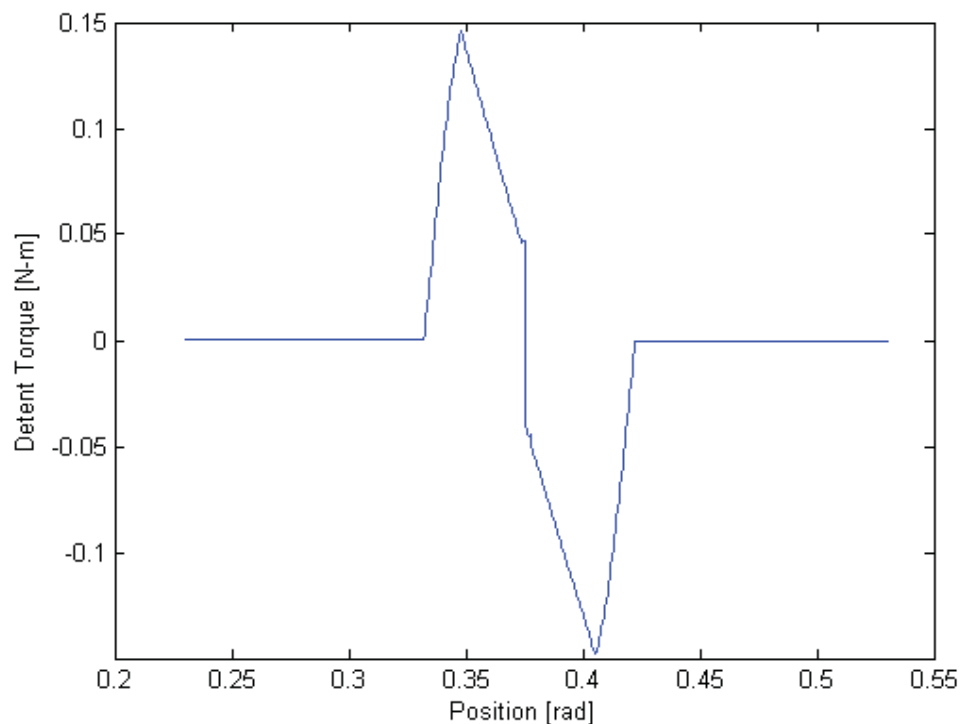
The Problem



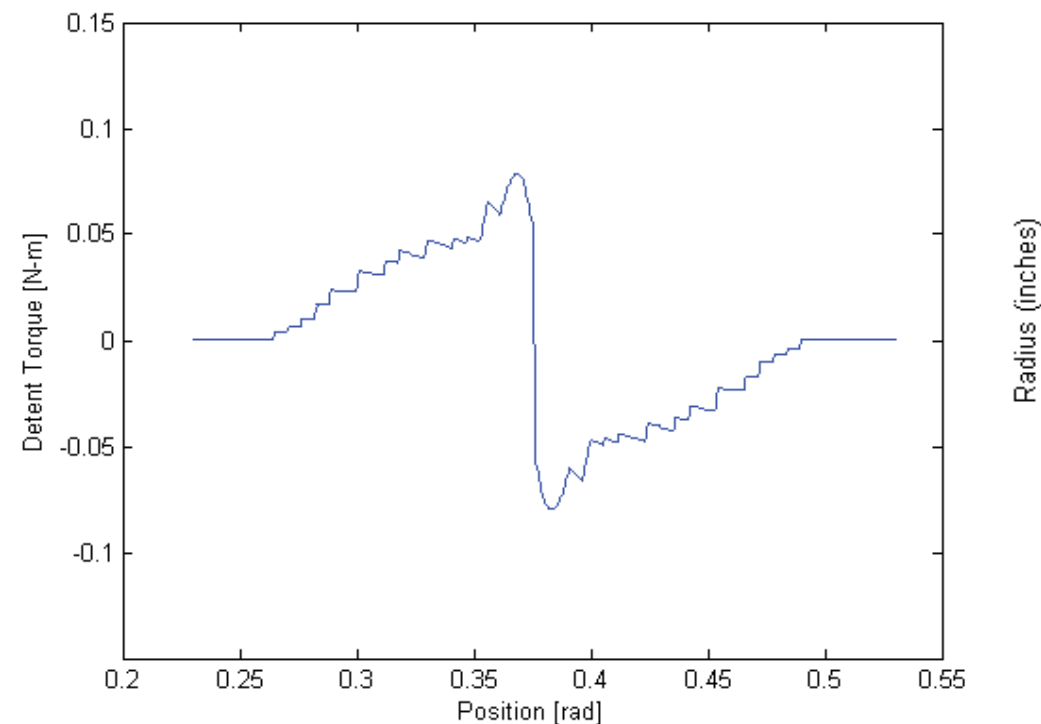
Detent Modification



- Torque Profile, Original Detent

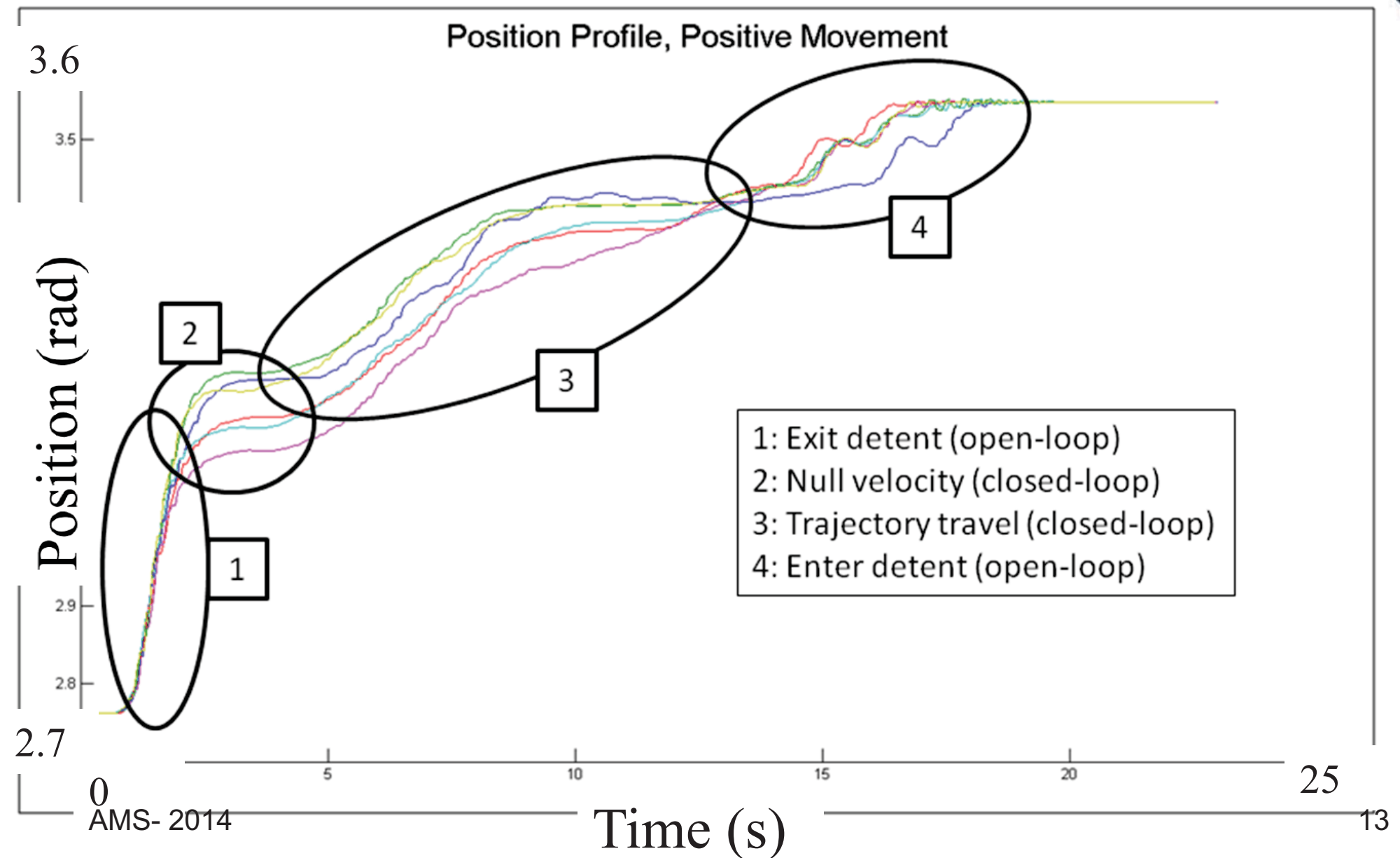


- Torque Profile, Modified Detent

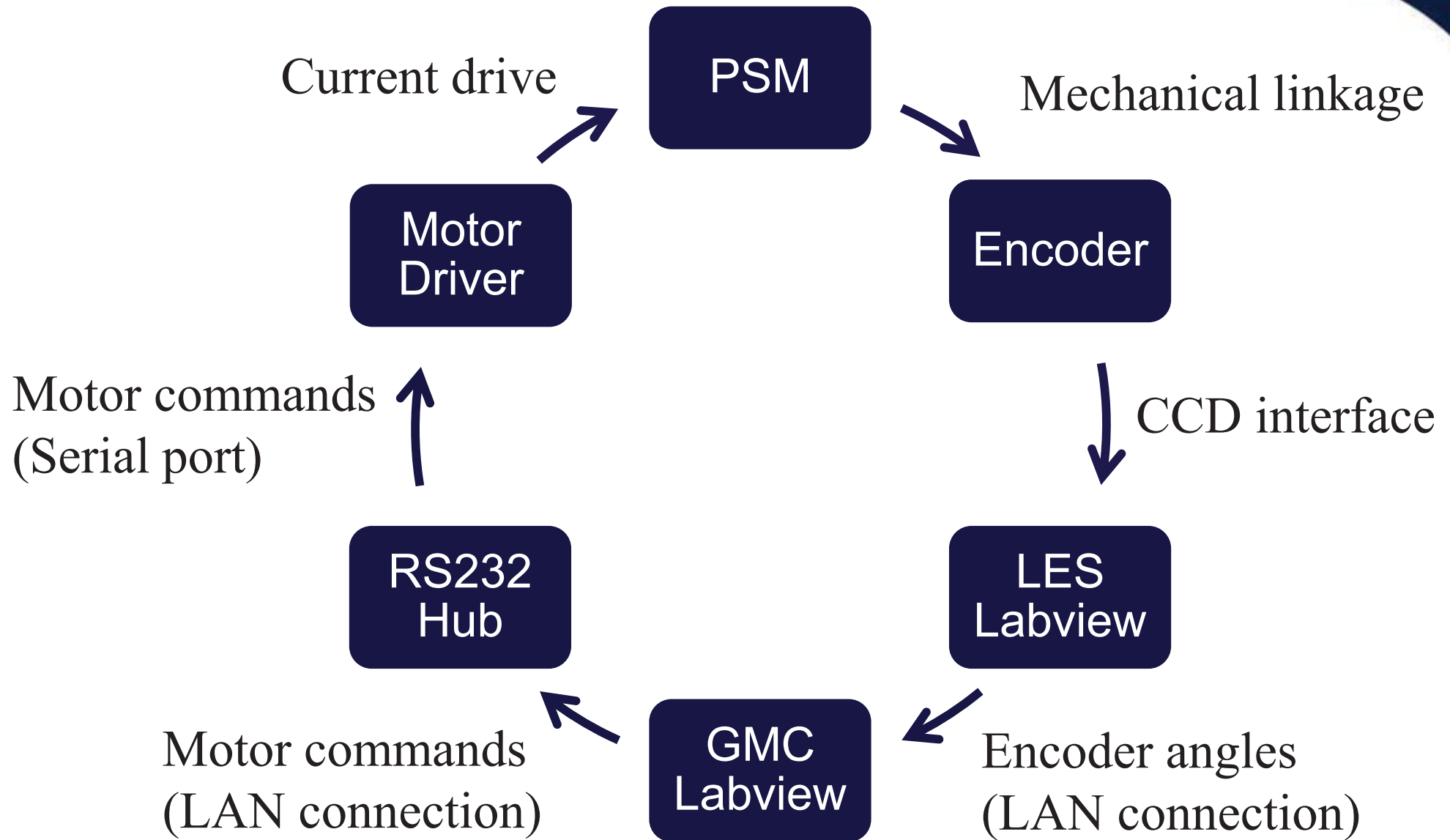


- Detent modification greatly reduced peak disturbance torque and reduced discontinuities.

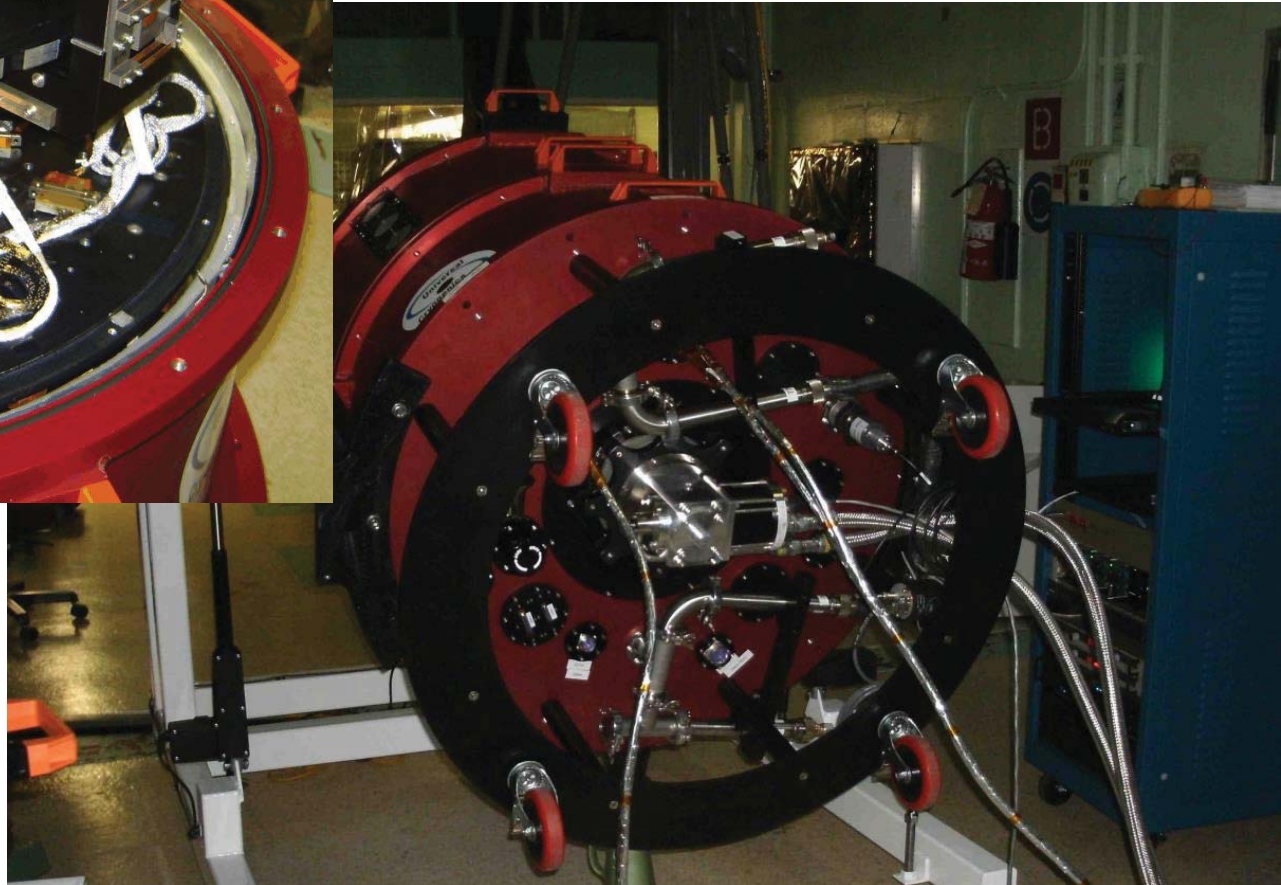
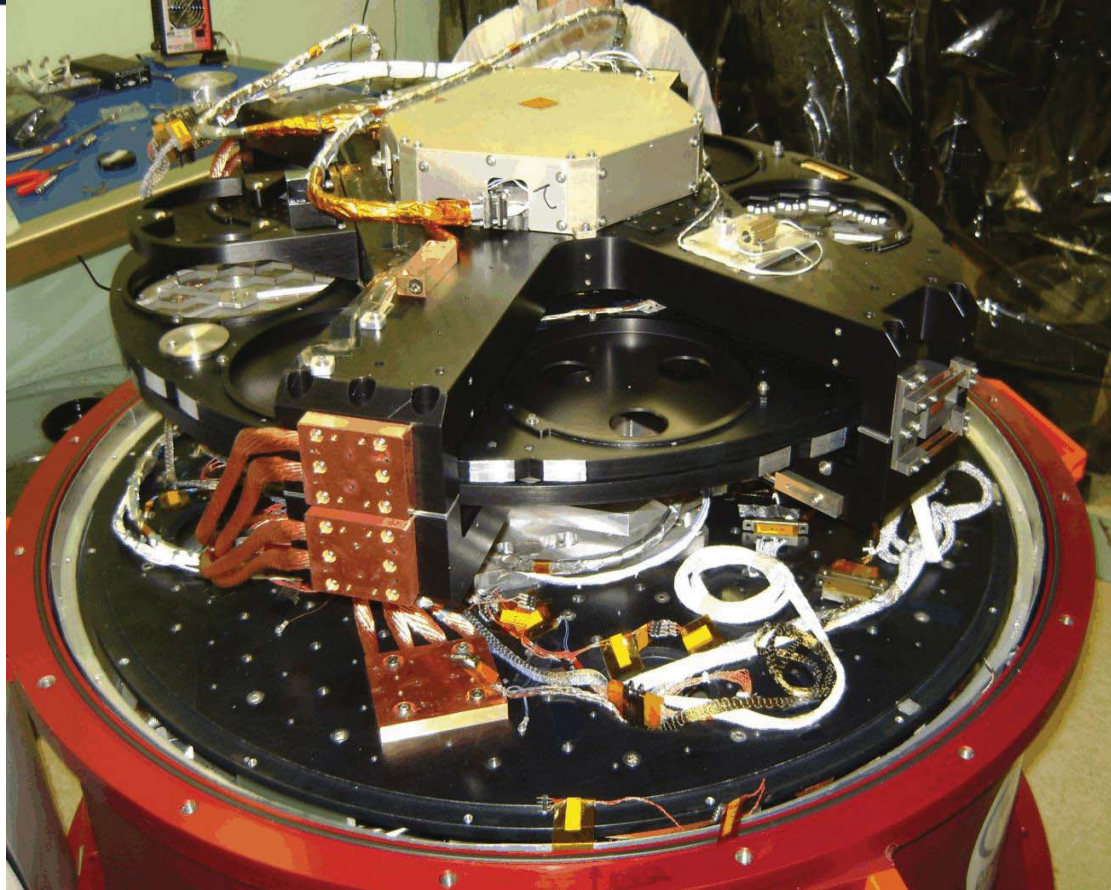
Mode-Switching Controller



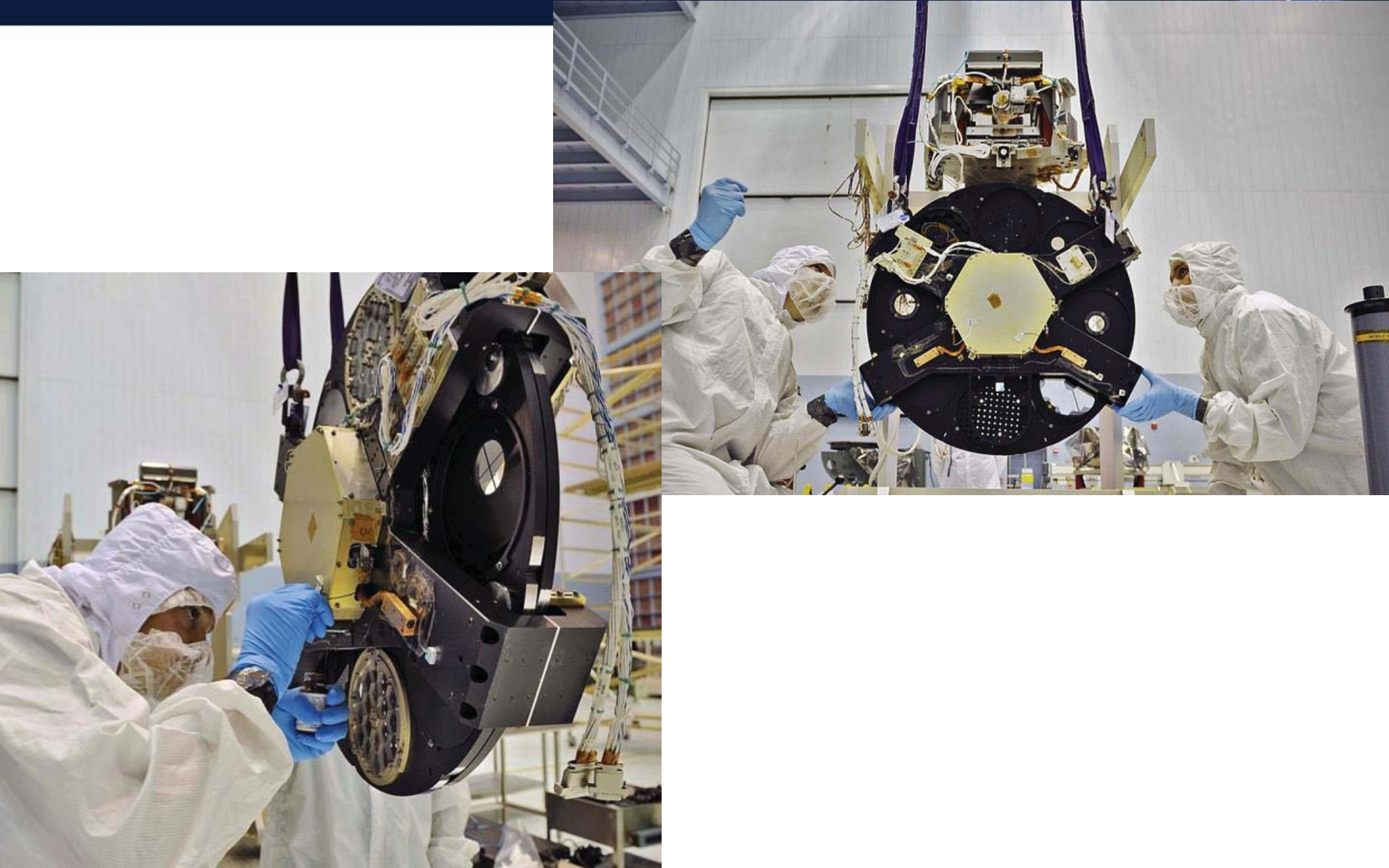
Control System Layout



Functional and Performance Testing



PSM Integration into OSIM



PSM Lessons Learned



- Motors and encoder/sensor selection are key decision points in an electromechanical system
- Cold treated hybrid bearings consisting of Si₃N₄ balls, Cronidur 30 races, and a PGM-HT retainer have been shown to be suitable for cryogenic operations
- When modeling a plant, ensure the plant is of a high enough fidelity to represent the dynamic response of the system accurately.
- Closed-loop control always needs a sensor with sufficient bandwidth and speed range.
- In a two-pole system, use high order compensator
- Automatic event logging is critical in systems with many operators

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